

CLAIMS

what is claimed is:

1. A method of depositing a dielectric film on a partially fabricated semiconductor device, the method comprising:
 - 5 exposing the partially fabricated semiconductor device to an aluminum-containing precursor gas to form a saturated layer of aluminum-containing precursor on the partially fabricated semiconductor device; and
 - exposing the saturated layer of aluminum-containing precursor to a silicon-containing precursor gas at substrate temperatures greater than about 250 degrees Celsius to form the dielectric film.
- 10 2. The method of claim 1, wherein the silicon-containing precursor further comprises oxygen.
- 15 3. The method of claim 1, wherein the dielectric film has a dielectric constant (k) of less than about 6.
4. The method of claim 1, wherein the dielectric film has a wet etch rate ratio (WERR) of less than about 5.
- 20 5. The method of claim 1, wherein the dielectric film has a post-anneal shrinkage percentage of about 5%.
6. The method of claim 1, wherein the dielectric film has a post-anneal compressive film stress of less than about 0.5 Gdyne/cm².
- 25 7. The method in claim 1, wherein the dielectric film is deposited over gaps in the partially fabricated semiconductor device.
- 30 8. The method in claim 7, wherein the dielectric film is deposited over shallow trench isolation (STI) features in the partially fabricated semiconductor device.
9. The method of claim 1, wherein the aluminum-containing precursor is at least one of hexakis(dimethylamino) aluminum and trimethyl aluminum.

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10. The method of claim 1, after exposing the partially fabricated semiconductor device to the aluminum-containing precursor gas, further comprising purging with an inert gas before contacting the saturated layer of aluminum-containing precursor with a silicon-containing precursor gas.
- 5 11. The method of claim 1, wherein exposing the partially fabricated semiconductor device to the aluminum-containing precursor gas occurs at substrate temperatures between about 250 and 300 degrees Celsius.
- 10 12. The method of claim 1, wherein contacting the saturated layer of aluminum-containing precursor with a silicon-containing precursor gas occurs at substrate temperatures between about 250 and 300 degrees Celsius.
- 15 13. The method of claim 1, wherein the silicon-containing precursor is at least one of a silanol and a silanediol.
14. The method of claim 1, wherein the silicon-containing precursor is at least one of tris(tert-butoxy)silanol ((C₄H₉O)₃SiOH) and tris(tert-pentoxo)silanol((C₅H₁₁O)₃SiOH).
- 20 15. The method of claim 1, after exposing the saturated layer of aluminum-containing precursor to a silicon-containing precursor gas at substrate temperatures greater than about 250 degrees Celsius, further comprising purging with an inert gas and exposing again the saturated layer of aluminum-containing precursor to a silicon-containing precursor gas at substrate temperatures greater than about 250 degrees Celsius to form an additional layer of dielectric film.
- 25 16. The method of claim 1, further comprising purging with an inert gas and repeating exposing the partially fabricated semiconductor device to an aluminum-containing precursor gas and exposing the saturated layer of aluminum-containing precursor to a silicon-containing precursor gas to form an additional layer of dielectric film.
- 30 17. The method of claim 1, wherein exposing the partially fabricated semiconductor device to an aluminum-containing precursor gas and exposing the saturated layer of aluminum-containing precursor with a silicon-containing precursor gas occur in the same reaction chamber.
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18. The method of claim 1, wherein exposing the partially fabricated semiconductor device to an aluminum-containing precursor gas and exposing the saturated layer of aluminum-containing precursor with a silicon-containing precursor gas occur in different reaction chambers in a multi-chamber apparatus.
- 5 19. The method of claim 1, after exposing the saturated layer of aluminum-containing precursor with a silicon-containing precursor gas to form the dielectric film, further comprising a performing post-deposition thermal anneal.
- 10 20. The method of claim 19, wherein the post-deposition thermal anneal comprises using substrate temperatures of between about 400 and 1000 degrees Celsius.
21. The method of claim 20, wherein the post-deposition thermal anneal comprises using substrate temperatures greater than 600 degrees Celsius.
- 15 22. The method of claim 19, wherein exposing the saturated layer of aluminum-containing precursor to a silicon-containing precursor gas and the post-deposition thermal anneal occur in different reaction chambers separate reaction chambers in individual apparatuses or in separate chambers as part of a multi-chamber apparatus.
- 20 23. The method of claim 1, wherein the flow rate of aluminum-containing precursor gas range between about 100 and 400 sccm.
24. The method of claim 1, wherein the flow rate of silicon-containing precursor gas range between about 200 and 1000 sccm.
- 25 25. A method of forming a dielectric film on a substrate, the method comprising:
depositing an aluminum-containing precursor gas to form a saturated layer of the aluminum-containing precursor on the partially fabricated semiconductor device;
30 exposing the aluminum-containing precursor of the saturated layer to a silicon-containing precursor gas to form the dielectric film; and
after forming the dielectric film, performing a post-deposition thermal anneal.
26. The method of claim 25, wherein the post-deposition thermal anneal comprises
35 using substrate temperatures between about 400 and 1000 degrees Celsius.

27. The method of claim 26, wherein the post-deposition thermal anneal comprises using substrate temperatures greater than 600 degrees Celsius.

28. The method of claim 25, wherein forming the dielectric film and performing the post-deposition thermal anneal the dielectric film occur in different reaction chambers.

29. The method of claim 25, wherein contacting the aluminum-containing precursor of the saturated layer with a silicon-containing precursor gas occurs at temperatures greater than about 200 degrees Celsius.

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30. The method of claim 25, wherein contacting the aluminum-containing precursor of the saturated layer with a silicon-containing precursor gas occurs at temperatures greater than about 250 degrees Celsius.

31. The method of claim 25, wherein contacting the aluminum-containing precursor of the saturated layer with a silicon-containing precursor gas occurs at temperatures between about 250 and 300 degrees Celsius.

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